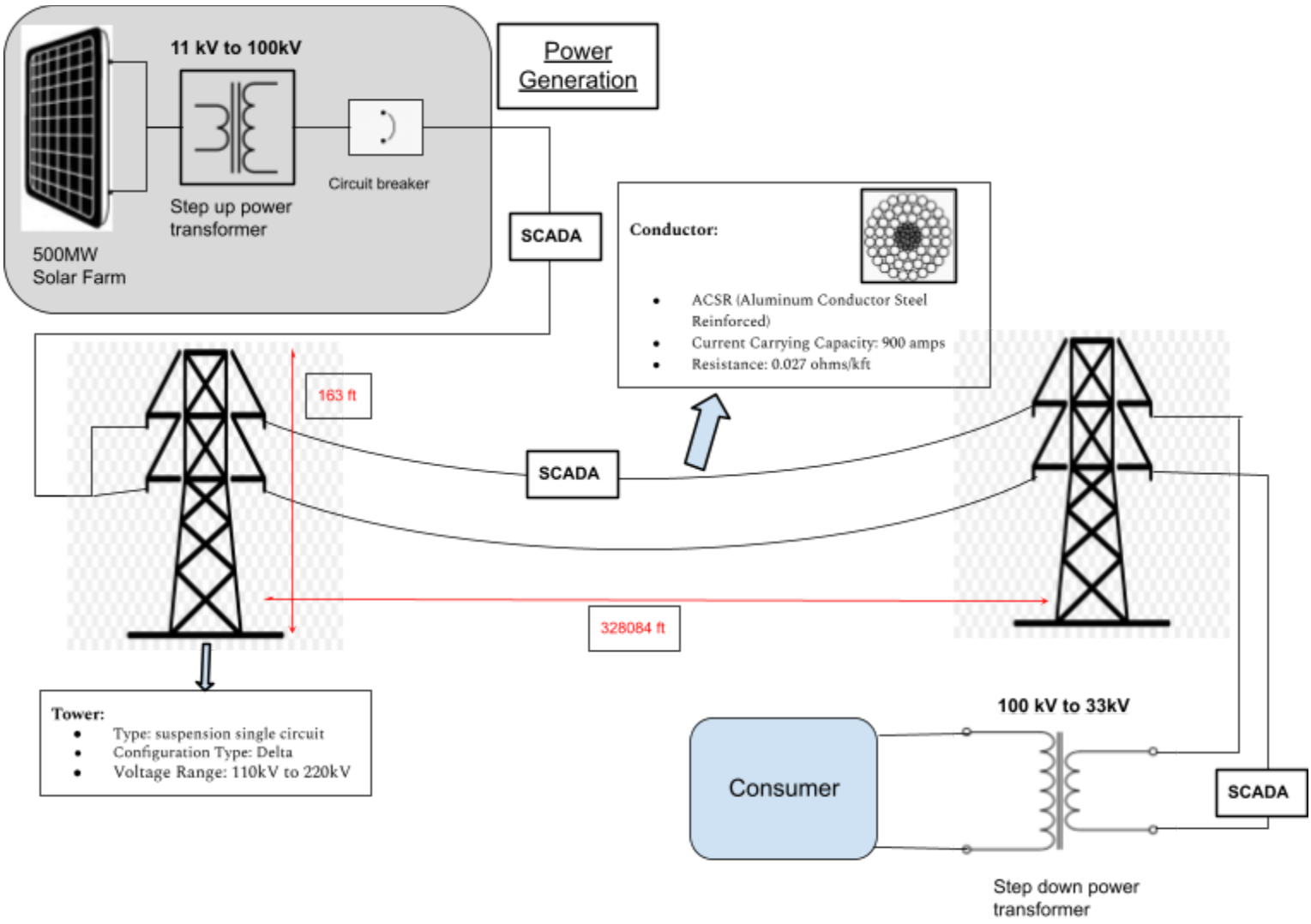
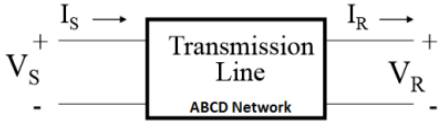
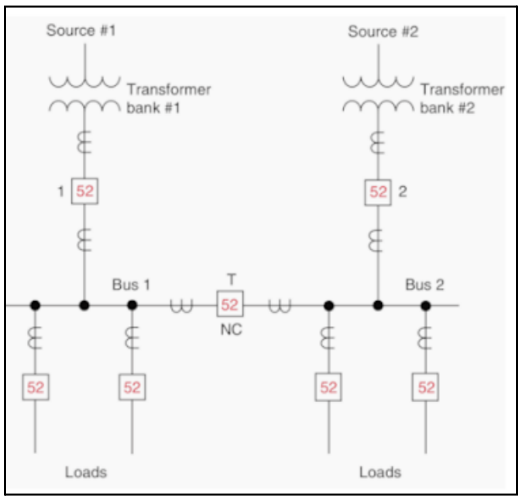


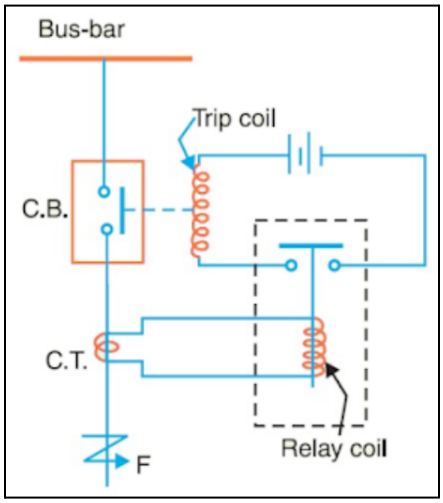
$$V_s = AV_R + BI_R$$
$$I_s = CV_R + DI_R$$



A	1.029
B	0.655+33.9j
C	0.0368
D	1.029



Transformer for protection



Relay for Line Protection

Université d'Ottawa
Faculté de génie

École de science informatique
et de génie électrique

University of Ottawa
Faculty of Engineering

School of Electrical Engineering
and Computer Science

ELG4125 Design Module 2

Designing a Solar Farm
Submission: October 30, 2022
Group 17

Submitted by:
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Conductor for overhead 100kV three phase transmission line:

Conductor of choice: ACSR (Aluminum Conductor Steel Reinforced)

- Stranded steel core with one or more layers of high purity aluminum (aluminum 1350) wrapped in a spiral
- Core wires are either galvanized or aluminized which helps protect steel from corrosion
    - Central steel core adds mechanical strength reducing sag
- Steel content range from 6% to 40%
- Can be used for all transmission and distribution purposes

We are using the ACSR 'Cuckoo' conductor which is mostly used for below 132kV transmission lines. 30 aluminum + 7 steel wire.

Parameters	Value
Current Carrying Capacity (amps) @ 75 degree C	900
Outside Diameter (inches)	1.092
Weight (lbs/kft)	749.9
Rated Voltage (kV)	132
Resistance DC (20℃) (ohms/kft)	0.0215
Resistance AC (75℃) (ohms/kft)	0.027
Series Inductive Reactance (Ω/km)	0.339
Shunt Capacitive Reactance (MΩ/km)	0.204
Frequency (hertz)	60

Tower Selection:

Tower of choice: Suspension Once Circuit

- Commonly used tower
    - One circuit typically used in Canada
- Forms an inverted Delta
- For 100kV we are assuming the transmission line is medium,, we will be using 100km for calculation purposes.
- Supports conductors vertically

Parameters	Values
Tower Type	Suspension
Voltage Range	110 kV to 220 kV
# of Circuits	Single Circuit
Configuration Type	Delta

Angle of Line Deviation	0° to 2°
Operating Temperature Range	0℃ to 75℃
Insulator Type	Suspension
Weight of insulator disk	3 KN
Weight of ground wire attachment	2KN
Wind span	300 m
Weight span	450 m

Transmission Line Model(ABCD)

resistance/km(DC)=0.0065532Ω/km

Resistance of each conductor, R	0.00655*100=0.655Ω
Resistance of each conductor, XL	0.339*100=33.9Ω
Total series impedance, Z	0.655Ω+33.9jΩ
Total shunt admittance, Y	1/(0.655Ω+33.9jΩ)=0.0005697-0.0294875jΩ
Receiving end voltage/Phase, VR	100000/(sqrt3)=57735V
Load power factor, PF	CosϕR = 1 lagging
Line current, IR	100 * 10^6 / (3 * 57735 * 1) = 577.35
A	1.029
B	0.655+33.9j
C	0.0368
D	1.029
Sending end Voltage/phase, Vs	1.029*57735+0.655*577.35=59787
Sending end Current/phase, Is	0.0368*57735+1.5*577.35=2990A
Sending end Power factor, PF	(57735*1+0.655*577.35)/59787=0.972, 97.2%
%age Voltage regulation	(59787-57735)/57735=0.0355,3.55%
Line loss	3*(577.35^2)*0.655=655kW
Input power	100000-655=99345kW

Transmission Line and Transformers Protection (against faults and lighting effects) :

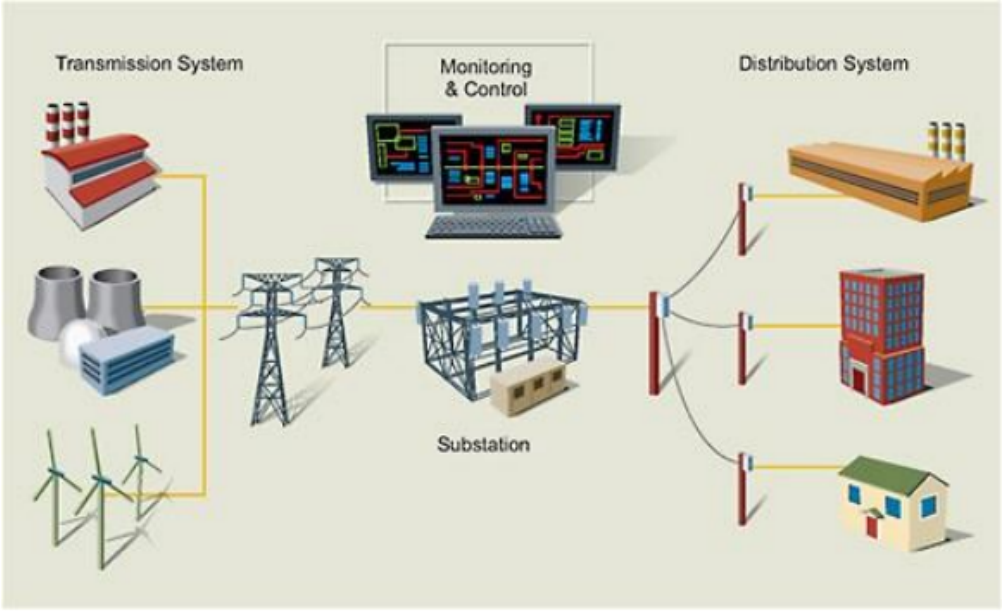
Transformers:

Potential Hazard	**Protections**
Lightning over voltages	ZnO surge arresters
Overheating	temperature control box
Overcurrent	IDMT relays
Earth Fault	Restricted earth fault protection relay

Transmission Line

Overload and Overcurrent	Circuit Breaker
Earth Fault	Restricted earth fault protection relay
Current Grading	IDMT relays
Lighting Strike	Static Shield Wire

SCADA System :



SCADA System	6NH7997-5CA21-0AA2 Siemens

Database Server: For saving real-time data from the network	SR665 Rack Server
Remote Terminals Units(RTUs): Installed in Solar Plants and Transmission Tower for collecting data from sensors and upload to network	Siemens TELEGYR SYSTEMS TG5700 TG 5700 RTU REMOTE TERMINAL UNIT CONTROLLER
Master Terminal Units (MTUs): A place in the substation for keeping all servers analyzing Data and controlling all RTUS	Substation
Shunt Capacitor Installed on transmission line	BFAM IEC 60871-1 Rated Capacity:150-500Var

Related IEEE Standard

● IEEE18-2012, IEEE Standard for Shunt Power Capacitors
● IEEE524-2003, IEEE Guide to the Installation of Overhead Transmission Line Conductors (Revision of IEEE Std 524 - 1992)
● IEEE 644-1994 (R2008), IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields From AC Power Lines
● IEEE Std 824™-2004,IEEE Standard for Series Capacitor Banks in Power Systems
● IEEE 977-2010, IEEE Guide to Installation of Foundations for Transmission Line Structures
● IEEE1048-2003, IEEE Guide for Protective Grounding of Power Lines

HVAC to HVDC